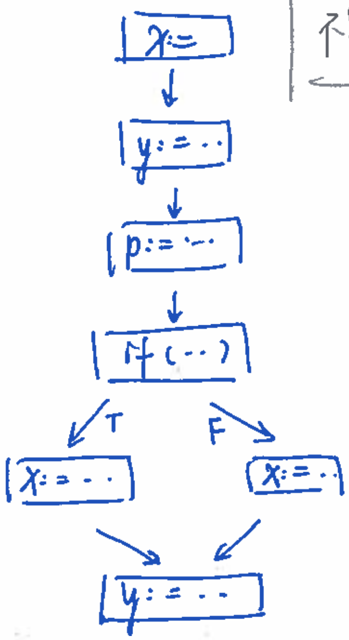
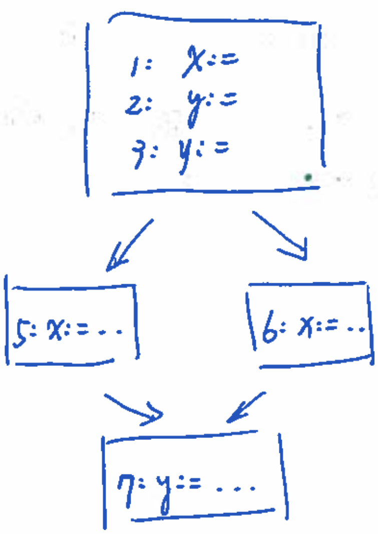
① CFG "C"

考试写这个
不要简化了.



visual sugar



② DFA: Eg1: Reaching Definitions

what assignments have set the value for variables

may-point-to

~~Safety:~~ Safety: can have more.

→ a set of var→stmt bindings

$\{x \to s_1, x \to s_2, y \to s_3\}$.

constraints:

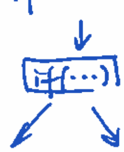
△ ~~S:t~~ $F^{s_i}_{x:=\ldots}(in) = in - \{x \to s' \mid s' \in stmts\} \cup \{x \to s^*\}$

△ $F^{s_i}_{*p:=\ldots}(in) = in - \{x \to s' \mid x \in must\text{-}point\text{-}to(p) \wedge s' \in stmts\} \cup \{x \to s \mid x \in may\text{-}point\text{-}to(p)\}$

*P是修改p指针指向的内容

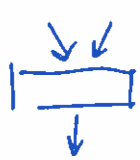
x是p指向的variable. 被改变.

△ if branch



out0 = out1 = in

△



out = ~~&~~ in0 ∪ in1

Reaching Definitions.

Flow Functions

Local

① do not constrained problems. → 初始为 ϕ. bottom $\perp$

② order? → topological order

↓

Loops. no order!

↓

worklist Algorithm

① order problems

② termination

(safe: stop at any time

else: must run it to completion (termination) to ensure safety)

: step 即 union

→ Join $\sqcup$

general pattern

[Lattice]

Global

a powerset Lattice

① order

$\top$ is always the safest. ⇒ going up is safe.

So start from top can get the most imprecise / conservative ans. Greatest Fixed Point

start from bottom: precise / optimistic

LEAST fixed Point (比 greatest 那个更 precise)

前提. F is monotonic

② termination: Lattice has a finite height

(need outer join) (length of the longest ascending or descending chain)

↓

if F is monotonic, + finite height ⇒ termination, without outer join

= global F

if local Fs 都 are monotonic

Reaching Definitions

$D \quad \sqsubseteq \quad \bot \quad \top \quad \sqcup \quad \sqcap$

may-point-to

$D = PowerSet(\{x \to s \mid x \in Vars \wedge s \in Stats\})$

$\top^{\boxed{safe}} = FullSet\ \{x \to s \mid x \in Vars \wedge s \in Stats\})$

$\bot = \phi$

$\sqcup = \cup$

$\sqcap = \cap$

$\sqsubseteq = \subseteq$

powerset analysis
同 may-must

但 eg. range
analysis 就不行了

Flow Functions: (前面写了).

$S: x := \ldots$

$S: *p := \ldots$

branch. merge.

Constant Propagation

$D \quad \sqsubseteq \quad \bot \quad \top \quad \sqcup \quad \sqcap$

must-point-to

$D = PowerSet(\{x \to N \mid x \in Vars \wedge N \in \mathbb{Z}\})$

$= 2^{\{x \to N \mid x \in Vars \wedge N \in \mathbb{Z}\}}$

$\top^{\boxed{safe}} = \phi$

$\bot = \{x \to N \mid x \in Vars \wedge N \in \mathbb{Z}\}$

$\sqcup = \cap$

$\sqcap = \cup$

$\sqsubseteq = \supseteq$

Constant Propagation

Flow Functions

$F_{x:=N}(in) = in - \{x \to *\}$
$\cup \{x \to N\}$

$F_{x:=y\ op\ z}(in) = in - \{x \to *\}$
$\cup \{\cancel{x \to y\ op\ z}\ x \to N \mid y \to N_1 \in in \wedge$
$z \to N_2 \in in \wedge$
$N = N_1\ op\ N_2\}$

$F_{x:=*y}(in) = in - \{x \to *\} \cup \{$

$F_{*x:=y}(in) = in - \{z \to * \mid z \in \text{may-point-to}(x)$
$\cup \{z \to N \mid z \in \text{must-point-to}(x) \wedge$
$y \to N \in in\}$
$\cup \{z \to N \mid (y \to N) \in in \wedge (z \to N) \in in\}$

$F_{*x:=*y+*z}(in) = F_{a:=*y;\ b:=*z;\ c=a+b;\ *x=c}(in)$

$F_{y:=G(\ldots)}(in) = \phi$

~~Constant propogation example:~~

$$\cancel{x := 5}$$
$$\cancel{V := 2}$$

Common sub-expression Elimination: must-point-to

$$D \quad \sqsubseteq \quad \bot \quad \top \quad \sqcup \quad \sqcap$$

$$\cancel{D=}\; S = \{ x \to E \mid x \in Vars,\ E \in Expressions \}$$

$$D = 2^S. \quad \top = \emptyset \quad \bot = S \quad \sqcup = \cap \quad \sqcap = \cup \quad \sqsubseteq = \supseteq$$

Flow Functions:

$$F_{x:=Y op z}(in) = in - \{ x \to * \} \cup$$
$$\{ * \to \ldots x \ldots \} \cup$$
$$\{ x \to Y \text{ op } z \mid x \neq Y \wedge x \neq z \}$$

$$F_{x:=Y}(in) = in - \{ x \to * \} \cup$$
$$\{ * \to \ldots x \ldots \} \cup$$
$$\{ x \to E \mid Y \to E \in in \}$$

backward problems

$F(out) = in$

Live Variables:

may-point-to:

$$D \quad \sqsubseteq \quad \bot \quad \top \quad \sqcup \quad \sqcap$$

$$D = Powerset(\{Variables\}) = 2^{Vars}$$

$$\top = \cancel{\{Vars\}} = Vars$$

$$\bot = \emptyset$$

$$\sqcup = \cup$$

$$\sqcap = \cap$$

$$\sqsubseteq = \subseteq$$

Flow Function:

(version1)

$$F_{x:=Y op z}(out) = out - \{x\} \cup \{Y, z\}$$

([illegible])

$$= out - \{x\}$$
$$\cup \left(x \notin out \,?\, \emptyset : \{Y, z\} \right)$$